We claim:

1. A device for fluid mixing and gas exchange comprising:

a housing defining a chamber for holding a liquid, wherein at least 1 wall of the chamber comprises a plurality of gas-permeable portions, and wherein the gas-permeable portions are selectively deflectable into the interior of the chamber.

2. The device of claim 1, wherein 1 wall comprises a plurality of gas-permeable portions.

3. The device of claim 1, wherein 2 walls comprise a plurality of gas-permeable portions.

4. The device of claim 1, wherein at least 2 walls comprise a plurality of gas-permeable portions.

5. The device of claim 1, wherein at least one wall of the chamber comprises at least 3 selectively deflectable gas-permeable portions.

6. The device of claim 1, wherein at least one wall of the chamber comprises at least 4 selectively deflectable gas-permeable portions.

7. The device of claim 1, wherein at least one wall of the chamber comprises at least 5 selectively deflectable gas-permeable portions.

8. The device of claim 1, wherein at least one wall of the chamber comprises at least 6 selectively deflectable gas-permeable portions.

9. The device of claim 1, wherein at least one wall of the chamber comprises between 6 and 10 selectively deflectable gas-permeable portions

10. The device of claim 1, wherein at least one wall of the chamber comprises at least 10 selectively deflectable gas-permeable portions.

11. The device of claim 1, wherein the total area of the selectively deflectable portions is at least 25% of the area of the wall that comprises them.

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12. The device of claim 1, wherein the total area of the selectively deflectable portions is at least 50% of the area of the wall that comprises them.

13. The device of claim 1, wherein the total area of the selectively deflectable portions is at least 75% of the area of the wall that comprises them.

14. The device of claim 1, wherein the selectively deflectable portions are spaced apart.

15. The device of claim 1, wherein the selectively deflectable portions are separated by non-deflectable portions of the wall.

16. The device of claim 1, wherein the selectively deflectable portions are substantially parallel to one another.

17. The device of claim 1, wherein the selectively deflectable portions have uniform widths in the plane of the wall that comprises them.

18. The device of claim 1, wherein at least one selectively deflectable portion has a nonuniform width in the plane of the wall that comprises the selectively deflectable portion.

19. The device of claim 18, wherein adjacent deflectable portions comprise complementary convex and concave regions.

20. The device of claim 1, wherein the volume of the chamber is at least 0.5 μl.

21. The device of claim 1, wherein the volume of the chamber is between 0.5 μl and 10 μl.

22. The device of claim 1, wherein the volume of the chamber is between 10 μl and 50 μl.

23. The device of claim 1, wherein the volume of the chamber is between 50 μl and 150 μl.

24. The device of claim 1, wherein the volume of the chamber is between 150 μl and 500 μl.

25. The device of claim 1, wherein the volume of the chamber is between 500 μl and 1 ml.

26. The device of claim 1, wherein the chamber is macroscopic.

27. The device of claim 1, wherein the ratio of the area of the wall of the chamber comprising deflectable portions to the volume of the chamber is at least 50/m.

28. The device of claim 1, wherein the ratio of the area of the wall of the chamber comprising deflectable portions to the volume of the chamber is between 50/m and 20,000/m.

29. The device of claim 1, wherein the ratio of the area of the wall of the chamber comprising deflectable portions to the volume of the chamber is between 100/m and 10,000/m.

30. The device of claim 1, wherein a deflectable portion is constrained so that it does not move along its perimeter when actuated.

31. The device of claim 1, wherein the deflectable portions are independently deflectable.

32. The device of claim 1, wherein at least some of the deflectable portions are not independently deflectable.

33. The device of claim 1, wherein at least some of the deflectable portions are deflectable in groups.

34. The device of claim 33, wherein the deflectable portions in a group deflect at the same time.

35. The device of claim 33, wherein the deflectable portions in a group deflect at different times.

36. The device of claim 1, wherein the deflectable portions form part of a continuous gas-permeable layer of material.

37. The device of claim 1, wherein the thickness of the deflectable portions is between 1-1000 μm.

38. The device of claim 1, wherein the thickness of the deflectable portions is between 5-500 μm.

39. The device of claim 1, wherein the thickness of the deflectable portions is between and 100-300 μm.

40. The device of claim 1, wherein the gas-permeable deflectable portions are deflectable at a rate between 1 – 1,000 Hz.

41. The device of claim 1, wherein the gas-permeable deflectable portions are deflectable at a rate between 10 - 500 Hz.

42. The device of claim 1, wherein the gas-permeable deflectable portions are deflectable at a rate between 25 – 200 Hz.

43. The device of claim 1, wherein the gas-permeable deflectable portions are permeable to oxygen.

44. The device of claim 1, wherein the gas-permeable deflectable portions have a diffusivity for O_2 greater than 1.0×10^{-5} cm^2/s.

45. The device of claim 1, wherein the gas-permeable deflectable portions have a diffusivity for O_2 greater than 2.0×10^{-5} cm^2/s.

46. The device of claim 1, wherein the gas-permeable deflectable portions have a diffusivity for O_2 greater than 3.0×10^{-5} cm^2/s.

47. The device of claim 1, wherein the gas-permeable deflectable portions are made of a material in which the solubility of O_2 is greater than 5×10^{-3} mol/Liter for air at 1 atm.

48. The device of claim 1, wherein the gas-permeable deflectable portions are made of a material in which the solubility of O_2 is greater than 1.0×10^{-3} mol/Liter for air at 1 atm.

49. The device of claim 1, wherein the gas-permeable deflectable portions have a permeability to O_2 of between 750 and 850 Barrer.

50. The device of claim 1, wherein the gas-permeable deflectable portions have a permeability to O_2 of between 850 and 1000 Barrer.

51. The device of claim 1, wherein the gas-permeable deflectable portions have a permeability to O_2 of between 400 and 750 Barrer.

52. The device of claim 1, wherein the gas-permeable deflectable portions have a permeability to O_2 of less than 400 Barrer.

53. The device of claim 1, wherein the gas-permeable deflectable portions are permeable to CO_2.

54. The device of claim 1, wherein the deflectable portions comprise an elastomeric material.

55. The device of claim 54, wherein the elastomeric material is PDMS.

56. The device of claims 1, 36, or 54 wherein the housing and the deflectable portions comprise different materials.

57. The device of claims 1, 36, or 54, wherein the housing and the deflectable portions comprise the same material.

58. The device of claims 1, 36, or 54, wherein the housing and the deflectable portions comprise an elastomeric material.

59. The device of claim 58, wherein the elastomeric material is PDMS.

60. The device of claim 1, wherein at least a portion of the housing is made of a material selected from the group consisting of: glass, plastic, or metal.

61. The device of claim 1, further comprising a substrate, wherein the housing is positioned on the substrate.

62. The device of claim 61, wherein the substrate forms a wall of the chamber.

63. The device of claim 1, each portion is deflectable by pressurizing a cavity in communication with the deflectable portion or by pressurizing a cavity in communication with a different deflectable portion.

64. The device of claim 1, wherein at least one deflectable portion is deflectable by pressurizing a cavity in communication with a different deflectable portion.

65. The device of claim 1, wherein each deflectable portion is in communication with a cavity.

66. The device of claim 65, wherein the cavities are not connected with one another.

67. The device of claim 63, wherein at least two of the cavities are connected with one another via a hollow region that has a substantially smaller cross-sectional area than the area of either cavity so that pressurization of a first cavity results in deflection of a deflectable portion in communication with the second cavity.

68. The device of claim 63, wherein the cavities are pressurized using a gas from a high pressure reservoir.

69. The device of claim 68, wherein the gas is humidified.

70. The device of claim 63, wherein the cavities are pressurized at a pressure ranging from 1 – 200 psi.

71. The device of claim 63, wherein the cavities are pressurized at a pressure ranging from 1-30 psi.

72. The device of claim 63, wherein the cavities comprise an assembly of tubes that are blind at one or both ends, and wherein at least some of the tubes are connected to a high pressure reservoir.

73. The device of claim 63, wherein the cavities comprise an assembly of tubes that are blind at one or both ends, and wherein each of the tubes is connected to a high pressure reservoir.

74. The device of claim 63, wherein the cavities comprise an assembly of tubes that are blind at one or both ends, wherein at least one of the tubes is connected to a high

pressure reservoir, and wherein the remaining tubes are interconnected with at least one other tube.

75. The device of claims 72, 73, or 74, wherein the connection to a high pressure reservoir is via a valve that controls pressurization of the tube.

76. The device of claim 63, wherein the cavities comprise an assembly of tubes that are connected to a high pressure reservoir, and wherein at least some of the tubes are connected to the atmosphere or to a low pressure reservoir at lower pressure than that of the high pressure reservoir.

77. The device of claim 63, wherein the cavities comprise an assembly of tubes that are connected to a high pressure reservoir, and wherein at least one of the tubes is connected to the atmosphere or to a low pressure reservoir at lower pressure than the high pressure reservoir, and wherein the remaining tubes are interconnected with at least one other tube.

78. The device of claim 76 or 77, wherein the connection to the atmosphere or to a low pressure reservoir is via a valve that controls flow of gas through the tube.

79. The device of claim 76 or 77, wherein the the cavities are connected at one end to a high pressure reservoir and at the other end to a valve which can be vented to the atmosphere or to a low pressure reservoir so that when a valve is closed, the corresponding cavity is pressurized, resulting in deflection, and when the valve is opened, gas flows through the cavity and the cavity is depressurized.

80. The device of claim 63, wherein the cavities are located within the housing.

81. The device of claim 63, wherein a deflectable portion separates a cavity from the interior of the chamber.

82. The device of claim 63, wherein at least some of the cavities are connected to an actuation interface port.

83. The device of claim 82, further comprising connecting means for connecting the actuation interface port to a high pressure reservoir or a low pressure reservoir.

84. The device of claim 82, further comprising an array of valves for controlling flow from the high pressure reservoir into the cavities or from the cavities to a low pressure reservoir or the atmosphere.

85. The device of claim 84, further comprising a manifold that interfaces the array of valves with the cavities.

86. The device of claim 1, wherein the chamber has at least one access port allowing introduction of fluid into the chamber or removal of fluid from the chamber.

87. The device of claim 1, wherein the chamber has at least two access ports allowing introduction of fluid into the chamber or removal of fluid from the chamber.

88. The device of claim 1, wherein the chamber has at least four access ports allowing introduction of fluid into the chamber or removal of fluid from the chamber.

89. The device of claim 1, further comprising a high pressure reservoir.

90. The device of claim 89, wherein the high pressure reservoir is filled with gas having a higher oxygen concentration than that in ambient air at standard temperature and pressure.

91. The device of claim 89, wherein the gas is humidified.

92. The device of claim 1, further comprising a low pressure reservoir.

93. The device of claim 1, further comprising a computer.

94. The device of claim 1, further comprising means for sensing a parameter selected from the group consisting of: pH, dissolved oxygen, optical density, substrate concentration, and product concentration.

95. The device of claim 94, wherein the sensing means comprises a fluorescence-based detector.

96. The device of claim 94, wherein the sensing means comprises a chemical detector.

97. The device of claim 94, wherein the sensing means is located within the chamber.

98. The device of claim 1, wherein the device comprises a plurality of chambers having selectively deflectable gas-permeable portions.

99. The device of claim 98, wherein each portion is deflectable by pressurizing a cavity in communication with the deflectable portion or by pressurizing a cavity in communication with a different deflectable portion.

100. The device of claim 99, wherein the cavities extend across multiple chambers so that pressurization of a single cavity results in deflection of a deflectable portion into each of the multiple chambers.

101. The device of claim 99, wherein the chambers and cavities comprise layers within an elastomeric block.

102. The device of claim 99, wherein the cavities comprise an assembly of tubes that are blind at one or both ends and that are connected either to a high pressure reservoir, a low pressure reservoir, to another tube, or to a combination of the foregoing.

103. A device comprising a set of tubes made at least in part of a gas-permeable material, wherein the tubes form portions of a wall of a chamber, and wherein the portions of the wall are selectively deflectable into the interior of the chamber.

104. A device comprising a set of tubes made at least in part of a gas-permeable material, wherein the tubes are separated from the interior of a chamber by a layer of gas-permeable material that forms a wall of the chamber, wherein the tubes are selectively pressurizable, and wherein pressurization of the tubes causes portions of the wall to deflect into the interior of the chamber.

105. A method of achieving mixing and gas exchange of a volume of liquid comprising the steps of:

(i) introducing a liquid into the chamber of the device of claim 1; and

(ii) actuating the device so as to repetitively deflect the deflectable gas-permeable portions into the chamber.

106. A method of achieving mixing and gas exchange in a volume of liquid comprising the steps of:

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(i) introducing the liquid into the chamber of the device of claim 63; and

(ii) actuating the device so as to repetitively deflect the deflectable gas-permeable portions into the chamber, wherein deflection is accomplished by pressurizing the cavities.

107. The method of claim 105 or 106, wherein the gas-permeable portions are deflected in a sequence that produces peristaltic action.

108. The method of claim 105 or 106, wherein mixing of two initially unmixed liquids is essentially complete within 1 minute of actuation.

109. The method of claim 105 or 106, wherein mixing of two initially unmixed liquids is essentially complete within about 10 seconds of actuation.

110. A method of culturing cells comprising:

(i) introducing cells and a liquid cell culture medium into the chamber of the device of claim 1; and

(ii) actuating the device so as to repetitively deflect the deflectable gas-permeable portions into the chamber.

111. A method of culturing cells comprising the steps of:

(i) introducing cells and a liquid cell culture medium into the chamber of the device of claim 63; and

(ii) actuating the device so as to repetitively deflect the deflectable gas-permeable portions into the chamber, wherein deflection is accomplished by pressurizing the cavities.

112. The method of claim 110 or 111, wherein the gas-permeable portions are deflected in a repetitive sequence that produces peristaltic action.

113. A method of making a device for fluid mixing and gas exchange comprising steps of:

(i) fabricating a first layer defining a chamber;

(ii) fabricating a second layer defining a plurality of cavities;

(iii) fabricating a third layer comprising a gas-permeable material; and

(iv) bonding the layers so that the third layer is interposed between the first and second layers so as to separate the chamber from the cavities and comprises

portions that are selectively deflectable into the chamber upon pressurization of the cavities.

114. The method of claim 113, wherein the third layer is fabricated as part of the first layer and forms a wall of the chamber.

115. The method of claim 113, wherein the third layer is fabricated as part of the second layer and forms a wall of the cavities.

116. The method of claim 113, wherein the first layer defines a plurality of chambers and wherein following step (iv) the cavities extend across the plurality of chambers.

117. The method of claim 113, wherein the cavities comprise an assembly of blind-ended tubes.

118. The method of claim 113, wherein the layers are fabricated from a gas-permeable elastomeric material.

119. The method of claim 113, wherein the first layer, the second layer, or both are fabricated from a material selected from the group consisting of: glass, plastic, or metal.

120. The method of claim 113, wherein the third layer comprises a PDMS membrane.

121. The method of claim 113, further comprising the step of interfacing the device to means for pressurizing the cavities.

122. The method of claim 121, wherein the means for pressurizing the cavities comprises an array of valves.

123. The method of claim 121, wherein the means for pressurizing the cavities comprises a high pressure reservoir.

124. The method of claim 113, wherein the chamber is macroscopic.

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